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FIELD TRIALS OF QUICK RELEASE HAND CONTROLS

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17. Abstract

The prototype of the Quick Release Hand Control Unit was designed for TDC by Davis Engineering, with the aim of facilitating the availability of rental cars to disabled drivers. The unit attaches to the floor, steering column yoke, brake pedal, and gas pedal and is secured at points of attachment by means of four locking pins which allow the controls to be installed in 3 to 4 minutes and removed in 1 minute. This report describes the field evaluation of this unit. For the trials, prototypes were installed in vehicles at three rental car concessionaires, two in Ottawa, one in St. John's, Newfoundland. Data were collected through questionnaires completed by installers (i.e. the rental car concessionaires) and disabled drivers who rented the cars throughout two summers. Analyses focussed on (i) the reactions of respondents to the unit and (ii) the relation between, on the one hand, reported problems of installation, removal, and operation and, on the other, design features of the prototype. Results indicate that, in general, concessionaires and drivers alike reacted positively to the unit. Moreover, although some problems were identified, these appear to be few and readily remediable through minor modifications to the unit and careful selection of the rental car and its options. The major changes required to render the prototype ergonomically suitable are (a) provision of larger locking pins with tapered ends, (b) incorporation of a stiffer spring into the accelerator tension mechanism, and (c) provision of a shorter control arm.

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17 Résumé

Ce rapport rend compte des essais en service du prototype de commandes manuelles amovibles, étudié par Davis Engineering pour le CDT, dans le but d'adapter les voitures de louage aux personnes à mobilité réduite. Les commandes sont fixées au plancher, à la colonne de direction, à la pédale de freinage et à la pédale de l'accélérateur par quatre goupilles, ce qui permet la pose du système en 3-4 minutes et la dépose en une minute. Trois entreprises de louage, dont deux à Ottawa et une à Saint-jean de Terre-Neuve, ont accepté de prendre en charge ces essais. Des questionnaires ont été utilisés pour connaître l'opinion des entreprises et des usagers handicapés à l'égard de ce dispositif, et ce tout au long de eux étés successifs. L'analyse des commentaires a porté 1) sur l'opinion des répondants et 2) sur le rapport entre, d'une part, les problèmes signalés (pose, dépose et manoeuvre) et, d'autre part, les caractéristiques du prototype utilisé. Les résultats montrent que, de façon générale, tant les entreprises que les usagers sont favorables, et que les problèmes signalés sont peu nombreux et facilement palliables par de légères modifications et une sélection plus judicieuse du type de voiture louée et des équipements facultatifs à bord. Trois détails importants intéressent cependant la mise au point du prototype; ce sont: a) utiliser de goupilles tronconiques de plus gros calibre, b) augmenter la raideur du ressort du mécanisme d'accélération, et c) raccourcir le levier de commande.

18 Mots-clés	19 Diffusion
Automobilistes handicapés, transport, commandes manuelles, pose, dépose, ergonomie.	Le CDT dispose d'un nombre limité d'exemplaires.

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1.0 INTRODUCTION

1.1 BACKGROUND

Employment and travel opportunities are becoming increasingly available to the physically disabled resulting in an increase in their demand for the use of rental vehicles.

The Transport Canada Advisory Committee for the Transportation Handicapped identified the desire of having rental cars with hand controls available in Canada. In order to overcome the low utilization rate of dedicated equipment, the concept of a "quick release" hand control system was approached. The resultant system would accomodate the hand controls unit being quickly and easily installed and removed from a conventional motor vehicle. Davis Engineering, in a previous contact, developed such a system.

The development of the "quick release" hand control system involved the consideration of needs of the handicapped, the regulations and licensing requirements and the technical requirements needed for a quick release hand control system. This was followed by the design, manufacture and functional testing of a prototype unit.

At this point, the need for long-term field tests to establish full ergonomic suitability with respect to disabled driver and car rental concessionaires was identified by the Transportation Development Centre.

The method applied to obtaining in field user data and the results of the ergonomic evaluation of the previously quick release hand control unit is presented in this report.

1.2 OBJECTIVES

The objectives of the study were to (a) identify any design features of the prototype system which might affect its function, convenience, and safety through ergonomic analyses with respect to its use by disabled travellers and to its installation and removal by rental car concessionaires, and (b) specify remedial measures. In this way, the project was meant to serve an overall objective of facilitating greater mobility of the disabled driver.

1.3 GENERAL APPROACH

The general approach to meeting the project objective was as follows:

- following project initiation, the participating concessionaires were contacted and the hand control units were installed in the new rental vehicles,
- the various handicapped organizations listed in Appendix I were contacted to inform them of the extension of the field trials,
- the field trials were conducted, with Davis Engineering providing technical support to the participating rental concessionaires,
- data collected from the field trials was reviewed and analyzed with particular emphasis on the ergonomic aspects of the hand control units. Some statistics pertaining to economic aspects of the hand-control units were also compiled, and
- the results of the study were documented.

A flow diagram illustrating the project methodology is shown in Figure 1.

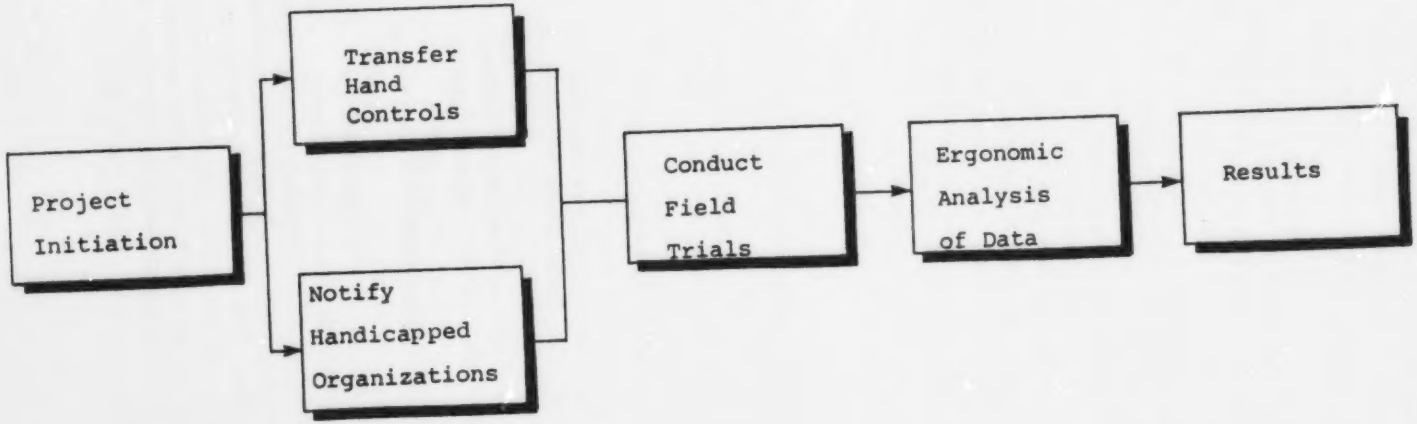


FIGURE 1 STUDY METHODOLOGY

2.0 METHOD

2.1 SUBJECTS

The study focused on the use of controls by disabled drivers as well as on their installation and removal by rental car concessionaires.

Letters were sent to all the major Canadian car rental agencies, inquiring as to their possible involvement in the field trials of a handicapped car rental service. The service was to be based on the "quick release" hand controls concept developed in previous contracts for the Transportation Development Centre (TDC). Three car concessionaires volunteered to participate. They were as follows:

Budget Rent-a-Car of Ottawa,
443 Somerset Street West,
Ottawa, Ontario.

Tilden Rent-a-Car Co.,
199 Slater Street,
Ottawa, Ontario.

Auto Host Car Rentals,
P.O. Box 5160,
St. John's, Newfoundland.

Drivers were confined to those having a valid driver's permit with the appropriate hand control restriction, full dexterity of both hands, and ability to operate a left-handed control unit. Data was collected from a total of 18 individuals, 3 from Budget, 11 from Tilden, and 4 from Auto Host.

2.2 EVALUATION STRATEGY AND INSTRUMENTS

The central thrust of the study was ergonomic, the aim being to pinpoint any design features of the hand control prototype system which may be problematic and to specify remedial measures. The data collection for these analyses was by means of two questionnaires, one for the concessionaires (Form C), the other for drivers (Form D). In both cases, a major section followed a functional task analysis format, with space for indicating difficulties and making comments for each element of the relevant task.

A second section of each instrument sought general information which would aid interpretation of the main body of data. In the case of Form C, this section covered details regarding general ease of installation and removal, the nature of maintenance, impressions of consumer acceptance, and rates of use. In Form D, it covered details of the trip made with the rented car, and information with respect to driving experience and previously use of hand controls. Form D also contained a section for open-ended comments on aspects of the hand control units, anxiety or discomfort experience while driving, and the nature of the concessionaire service.

The questionnaires appear in Appendix II of this report.

Cost information was also of interest since it might be expected that rental car concessionaires would react on a cost/benefit basis to pressure to provide a service to the disabled. Data for the cost/benefit analysis are based on estimates of the service being offered and inferences from questionnaire responses.

2.3 PROCEDURES

2.3.1 Installation/Transfer/Maintenance of Hand Controls

The necessary vehicles from the chosen car rental concessionaires were supplied to the Davis Engineering shops in order to be outfitted with the adaptor brackets for the quick release hand controls. The modified hand control units were then installed in each vehicle, and tested for adjustment, location, function, and integrity. Any final adjustments were made to the units prior to the vehicle's return to the concessionaire.

The concessionaires involved in the survey typically operate a rental vehicle (purchased new) for twelve months or 40,000 kilometres, whichever comes first. A heavily used rental unit can accumulate this kilometerage limit in as little as six months. Therefore, at one point during the study, all of the Ottawa-based rental vehicles involved in the original study were either approaching, or already exceeded this limit. For this reason, the transfer of hand-control units from the vehicles slated for disposal to newer vehicles was necessary. This involved removing the hand control bracketry from the older rental vehicles, installing into the new ones, and adjusting the hand control system to fit the new cars. Every effort was made to obtain the same makes and models of vehicles to minimize the time and effort required to complete the transfer.

During the field trial period, Davis Engineering serviced the hand control units when required. In-field failures of the units were noted, and immediate retrofits were made in the interest of providing greater safety and ensuring continuous service.

2.3.2 Advertisement of Service

The availability of the service to handicapped travellers was made known to various handicapped organizations (i.e., C.O.P.O.H., The Rehabilitation Institute of Ottawa, and l'Association des Paraplégiques du Québec) in order to help initiate the usage of the service. These organizations generally cater to various needs of the physically handicapped.

The rental car concessionaires were also encouraged to include exposure of this feature in their regular advertising campaigns. This was supplemented by "over-the-counter" efforts on the part of the concessionaires.

In addition, the hand control units were published in the local newspaper under a section geared for handicapped readers: Handilines offered by the Ottawa Citizen as a monthly service.

A list of the contacted organizations can be located in Appendix I.

2.3.3 Collection of Data

Trials began in July 1983 and ended in November 1984. During this time, the rental car concessionaires gave a driver questionnaire to each disabled person requesting a rental car, with a request to return the completed instrument at the end of the trip. The concessionaires completed their questionnaires before the end of the field trial period.

During this period, Davis Engineering monitored use of the units by handicapped drivers through collection of the questionnaires on a regular basis.

3.0 RESULTS AND DISCUSSION

3.1 DATA PRESENTATION

Task analysis information for the three rental car concessionaires appears in Table 1; remaining concessionaire responses are summarized in Appendix III on relevant parts of Form C. Responses obtained from the 14 drivers are presented in a similar manner. Their task analysis data are summarized in Table 2; a summary of remaining driver responses appears in Appendix IV on relevant parts of Form D. In all cases, frequencies, or means and standard deviations, are presented where applicable; for convenience, responses to open-ended items are paraphrased.

3.2 RESPONSE RATE

In the 16 month period of the evaluation, a representative of all three rental car concessionaires completed Form C; in one case an additional completed form was received, this making a total of four.

Only 14 drivers took advantage of the new service. This low response rate can be attributed, at least in part, and despite advertising efforts, to a low level of public awareness. In addition, however, it must be said that the period included 16 months of winter and generally low tourist activity. A psychological factor may also have been at work as people often wait until a new service is well established before taking advantage of it. One concessionaire mentioned under "projected demand" on Form C that demand could be increased if units were commercially available.

3.3 NONDISABLED CONSUMER ACCEPTANCE

Only two points were raised by nondisabled consumers renting cars with bracketry for the hand controls installed. The first of these was to the effect that, on a certain model of car, the gas pedal bracket extends out too far; therefore, the able-bodied driver's big toe rests on the bracket and interferes with the gas pedal operation. A diagram of the problem is shown in Figure 2. The solution lies in ensuring the the bracket is placed along the gas pedal armature so as to avoid this interference.

CONCESSIONAIRE'S QUESTIONNAIRE FORM C

OPERATION	DIFFICULTIES			REMEDIAL ACTION
	yes	no	Problem description	Problem Solution
INSTALLATION				
1 Position unit in car with columns toward floor and handle toward left	0	4		
2 Position attachment point on main column of assembly to bracket on steering column; insert shoulder locking pin from right to left through bracket and main column holes; insert hitch pin through hole at end of locking pin	0	4		
3 Position end of main column into floor bracket; insert locking pin from left to right through bracket and main column holes	2	2	- not a lot of room to insert pin	- design pins so they are easier to install
4 Position brake rod on brake pedal bracket; insert locking pin from left to right through bracket and brake column holes	0	4		
5 Position accelerator rod on throttle bracket; insert locking pin from left to right through bracket and accelerator rod holes	0	4		
6 To adjust accelerator tension, rotate collar on spring at base of main column; lock with wing nut bolt	1	3	- not enough tension - adjustment sometimes time consuming	- stiffer spring - larger wingnut for more leverage
REMOVAL				
1 To release accelerator tension, loosen wing nut bolt at base of main column; loosen collar on spring	0	4		
2 Grab ring in locking pin in brake pedal bracket; pull pin out leftward	0	4		
3 Grab ring in locking pin in throttle bracket; pull pin out leftward	0	4		
4 Grab ring in locking pin in floor bracket; pull pin out leftward	1	3	- space limitation	
5 Remove hitch pin from shoulder locking pin; grab ring of shoulder locking pin; pull out rightward	0	4		

TABLE 1 SUMMARY OF TASK ANALYSIS INFORMATION: CONCESSIONAIRE QUESTIONNAIRE

OPERATION	DIFFICULTIES			IMPROVEMENT WITH PRACTICE				Remedial Action
	yes	no	Problem description	none	some	very much	n/a	Problem Solution
Starting up	2	12	- Stalling	4	0	1	9	-Vehicle tune-up familiazation with control
Getting up to speed	1	13		2	3	0	9	
Maintaining fast speed	2	12	- Control touched knee	3	2	0	9	-Shortening of control arm -installation adjustment
Slowing down	1	13		2	2	0	10	
Stopping	3	11	- Gear Sticks - Control arm touches windows crank	3	0	1	10	-Installation adjustement -shortening of Control Arm
Turning right	2	12	- Turn indicator too close	2	2	0	10	-Spinner knob suggested
Turning left	2	12		3	2	0	9	-Spinner knob suggested
Switching lanes	1	13	- Signalling difficulties	4	0	0	10	-Spinner knob suggested
Passing a vehicle	2	12	- Control touches knee	3	2	0	9	-Shortening of control arm -Installation adjustment
Backing up	0	14		3	0	0	11	
Parking: - parallel	1	13		3	1	0	10	
- other	0	14		3	0	0	11	
Signalling	3	11	- Problems at full throttle (or brake) - too many levers for 1 hand	3	0	0	11	
Using windshield wipers	1	13	- See signalling	3	0	0	11	
Using dimmers	2	11	- See signalling	3	0	0	11	
Using emergency brake	4	5	- Foot operated	3	0	0	11	-Use hand to operate pedal
Adjusting mirror	4	10	- See signalling	2	0	0	12	
Removing wheelchair	6	5	- Console hinders process	5	2	0	7	-Shoulder height bucket seats required with no console. -folding bench seats
Stowing wheelchair	5	5	- Console hinders process	4	2	0	8	-Shoulder height bucket seats required with no console. -Folding bench seats.
Other (specify)								

TABLE 2 SUMMARY OF TASK ANALYSIS INFORMATION: DRIVER QUESTIONNAIRE

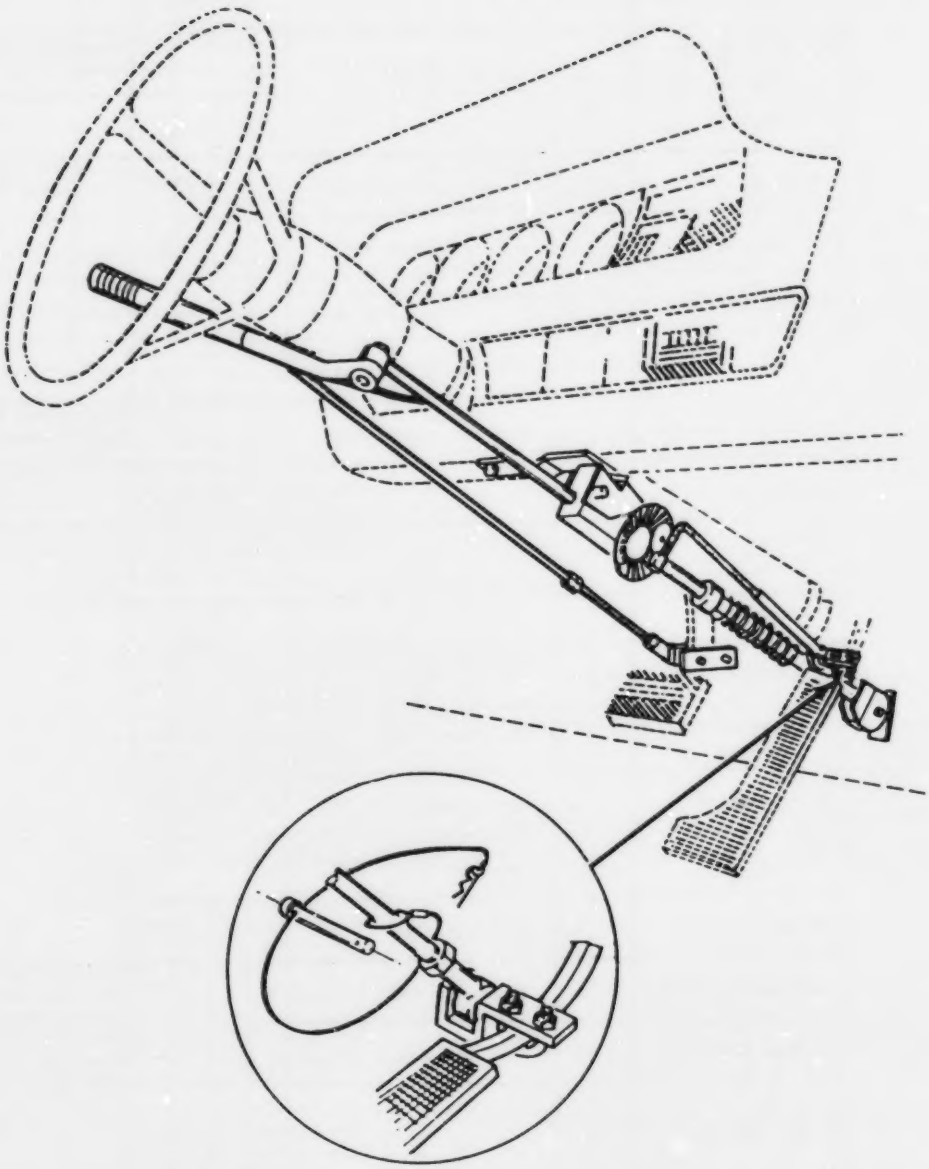


FIGURE 2 DIAGRAM OF HAND CONTROL WITH ACCELERATOR BRACKET DETAIL

A second comment pertained to a small degree of chrome flaking on some brackets, which occurred after some time in service. This problem is readily solved by using a higher grade of chrome plating for the production model.

3.4 DRIVER AND TRIP CHARACTERISTICS

The driver questionnaire included a section prompting the hand control user to give some brief details on his or her trip. The actual condensed information from the 14 drivers can be found in Appendix III. In briefly summarizing the population sampled; the majority of the sample was male, between the ages of 21 and 34, had obtained on average, 18 years driving experience with some form of hand control unit similar to the unit offered for the service, and obtained that experience while operating a mid-sized car. The average rental consumed 410 kilometres, 64% of which took place in the city, 29% on the highway and the remainder in a rural setting. The average rental period lasted approximately 7 days, almost 4 hours of which was actually spent behind the wheel. And, lastly, the dominant reason for the disabled driver renting the car was for the business purposes.

3.5 ERGONOMIC ANALYSES

3.5.1 Concessionaire Task Analysis

From Table 1 it will be clear that concessionaires reported difficulty with only three task elements, namely, numbers 3 (main column attachment) and 5 (adjustment of accelerator tension) of the installation operation, and number 4 (removal of ring from locking pin in throttle bracket) of the release operation. As direct observation of the installation and removal process demonstrates, because of the design of the vehicle the individual must contort himself into uncomfortable or disadvantageous positions.

Main Column Attachment

At any rate, the space limitations confining the attachment of the base of the main column are due to the close proximity to the brake and gas pedal. This situation is a classic example of the existing car design constraining the ergonomic design of the device to be installed in the car. Because this location is crucial to the stability and functionality of the design, the only other course of action is to attempt to ease the effort involved in inserting the locking pick in place.

This could be accomplished by enlarging the hole through the bracket and tie rod end, and servicing it with a large locking pin with tapered ends. This would reduce the effort needed to thread the two together. Figure 3 shows the present and the proposed design. This retrofit could be done on all locking pin connections to ease the installation process, as well as the task of removing the locking pin from the floor bracket.

Adjust Accelerator Tension

Figure 4 illustrates the design of the accelerator return mechanism. Apparent problems here include, (i) not enough tension can be applied and, (ii) adjustment sometimes time consuming.

The solutions to the above are relatively simple: (i) incorporate a stiffer spring into the design and, (ii) use a larger wing nut for more leverage.

3.5.2 Driver Task Analyses

The driver questionnaire will be reviewed on an item by item basis of the responses in Table 2.

Starting Up

Of the 14 rental drivers, two had difficulties "starting up" the vehicle with no major improvement from practice. Two possible explanations exist here. The vehicle required a tune-up at the time, or the operator was experiencing initial unfamiliarity with the device. An untuned vehicle is unlikely due to the fact that rental agencies do not rent out untuned vehicles. If they did, that would illustrate bad business and more than likely result in loss of business. The operator being unfamiliar with the hand control unit and the car model seems to be a more viable explanation. The majority of users noticed no improvement with practice. This fact would suggest that overcoming the initial hesitation of a new hand control unit and an unfamiliar car is a more intense matter than a similar situation for an able bodied driver. Otherwise stated, the learning curve for a physically handicapped driver is not as steep as one would first anticipate. Although every "niche" in a design is to be addressed and an attempt made to arrive at a better design, it is felt that the solution to the above problem is beyond this design of the quick release hand controls unit.

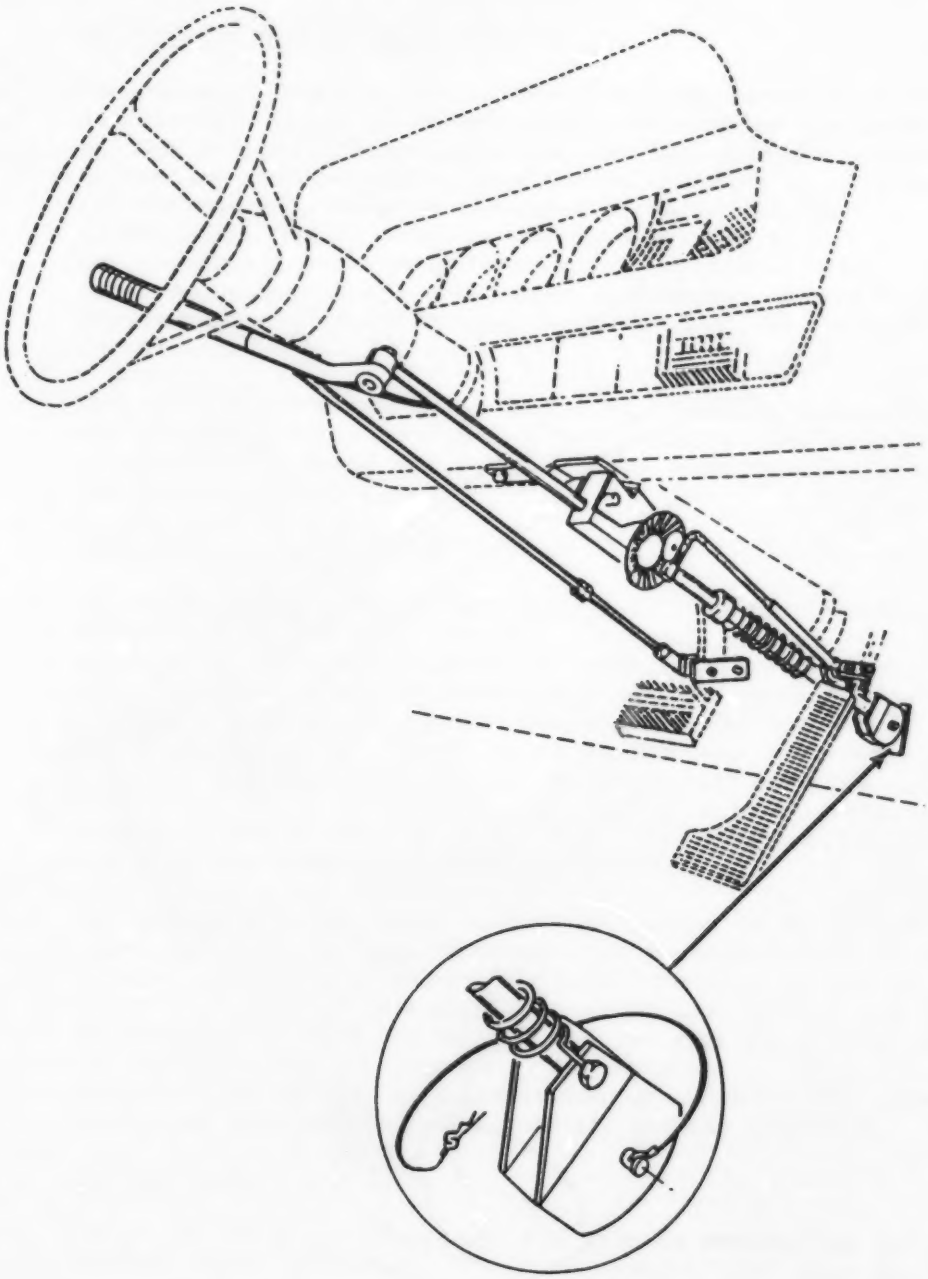


FIGURE 3 DIAGRAM OF HAND CONTROL WITH MAIN COLUMN ATTACHMENT DETAIL

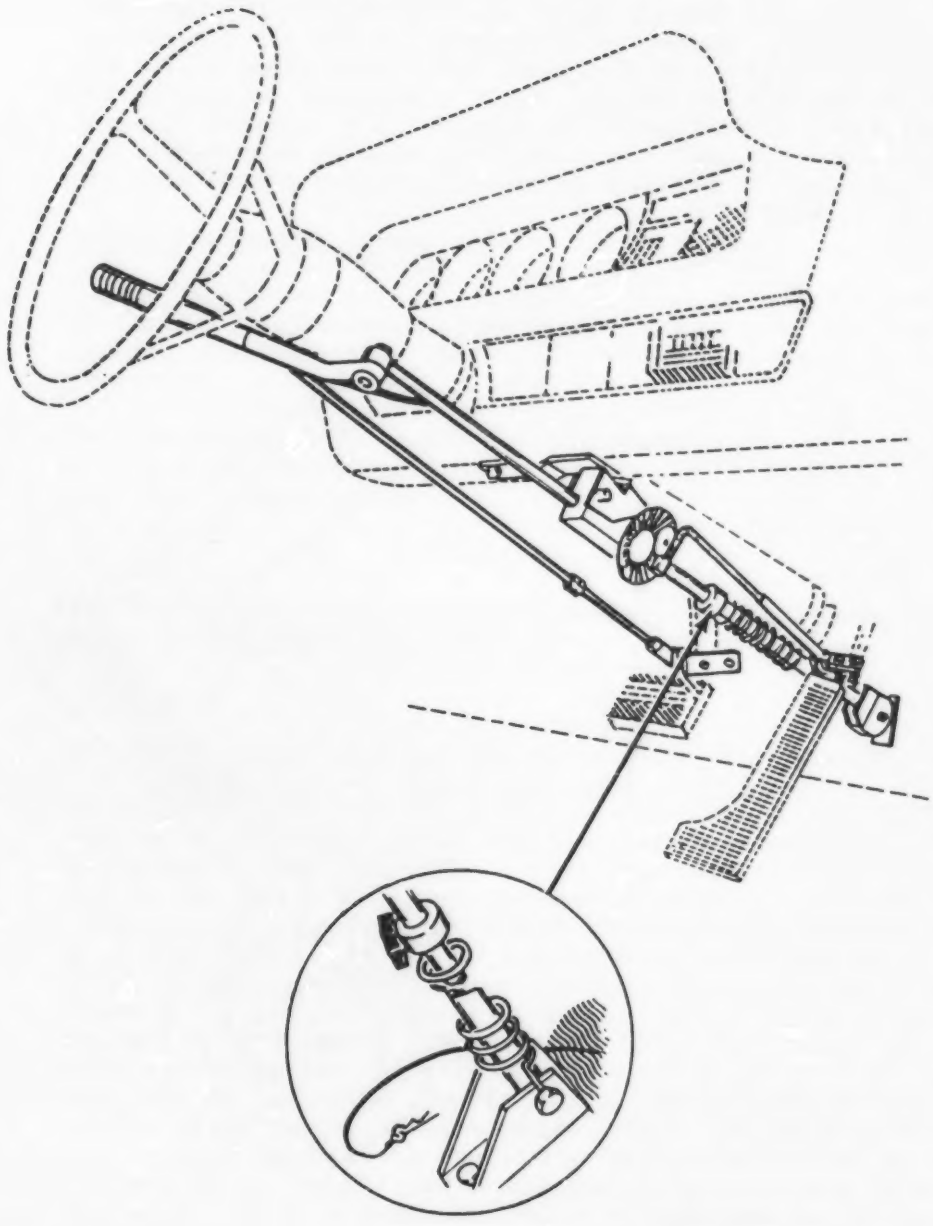


FIGURE 4 DIAGRAM OF HAND CONTROL WITH ACCELERATOR TENSION ADJUSTMENT DETAIL

Maintaining Fast Speeds

The comment, "control arm touches knee" was noted by 2 of the 14 drivers. Figure 5 (a) pictorially illustrates the mechanics of the problem. Also shown is the two possible solutions offered to the problem. Solution (b) consists of shortening the control arm, reducing the range of motion in which the end of the level travels thus, giving the knee more room. Solution (c) involves a final adjustment upon each installation. This final adjustment would entail the realignment of the control arm to ensure that it is positioned as close to the steering column as possible.

The combination of these two tentative solutions would alleviate this and other problems. For example, the operations: stopping and passing and vehicle could both benefit from the solution prescribed here.

Stopping

Two comments arose under this operation. "Control arm touches window crank" and "gear sticks". The two courses of action outlined in the previous point may eliminate the first problem area. Another added option would be the use of electric windows. This would remove the obstruction altogether. An accident during the field trial period was recorded. The accident occurred during the operation of stopping. Even though the damage to the car was minimal, all accidents are a serious matter. But it seems that the solution needed to eliminate the problem is quite a simple one.

The second problem, "gear sticks" is thought to be a misfiled comment due to the fact that there is no gear travel or even engaged during the braking action: The throttle action is the motion that involves the spur gear on the main column. If this is the case, a loose fit between the two spur gears (Figure 6) is the cause of the problem. The solution to this element could be included in an installation adjustment. The adjustment would involve ensuring a good fit between the gears.

Turning Right

"Turn indicator too close" was the problem description for the turning right operation. It is envisaged that this problem stems from signalling during the braking process. The relocation of the control arm, possibly to the right of the steering column is not a feasible solution due to the fact that, the signalling action would now require the operator to let go of the steering wheel. This is obviously an unacceptable coarse of action.

Any form of renovation to the signal indicator lever is not a viable solution. It is beyond the scope of this study to impose any alterations to the design of the car. The reality of designs such as the quick release hand control unit is that they are bound by the constraints of the design of car. This is apparent throughout this section. Ergonomic problems of hand controls are constrained by the car design.

In summary, it is felt that the existing design is the best possible solution, given the constraints of the "quick release" scheme and the car. Problems in operation of the unit, more specifically, signalling, should decrease with exposure to the unit and confidence in operation.

Spinner knobs seem to have been requested frequently as an aid to turning and signalling and should be offered as a partial improvement to the problem.

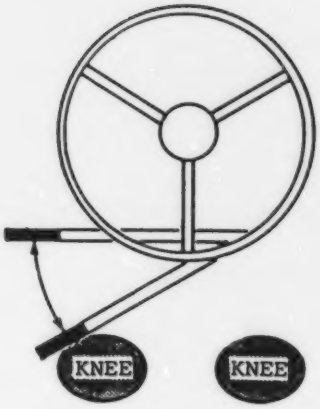
Removing Wheelchair

In removing and stowing the wheelchair, the console in the rental cars proved to be an obstacle. The process of stowing or removing a wheelchair in a car involves the disabled driver situating him or herself past the centre of the car, facing the driver door in order to tilt the driver seat forward and reach behind the seat to stow or remove the wheelchair.

The solution to the noted problem would be the use of folding bench seats, preferably shoulder height. The bench seat eliminates the console obstacle and the shoulder height seat would allow the driver to use his or her elbows on the seats to aid in maneuvering throughout this operation. Another option noted to aid a handicapped driver in entering and exiting the car is tilt steering. Because this option is similar to air conditioning or other "luxury" options, a certain surcharge would want to be levied. While this ergonomic problem is not related to the design of the hand controls, it is one which would affect use of the rental cars.

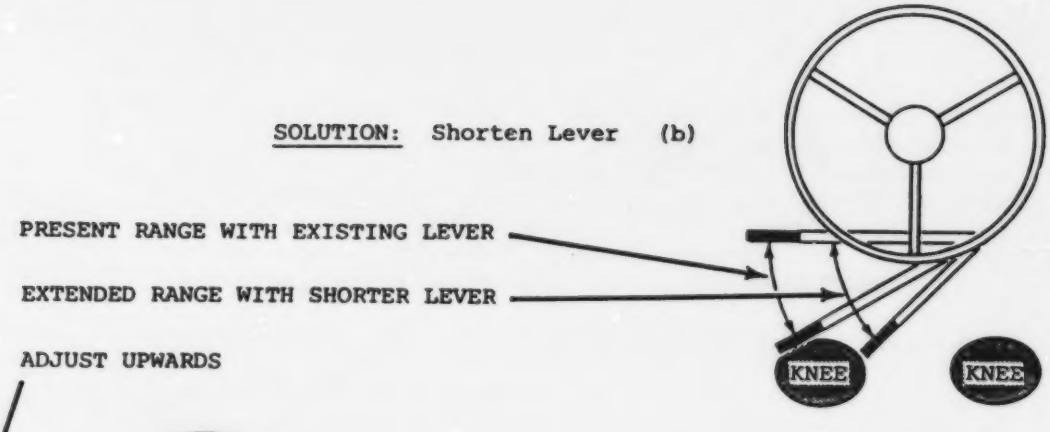
General Comments

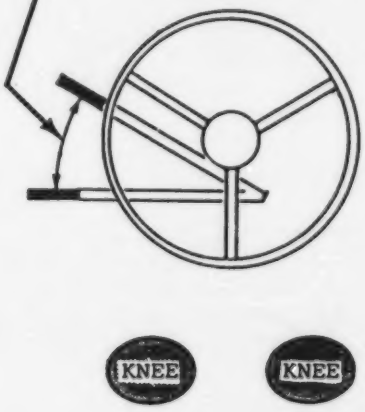
The following paragraphs are the expansion of selected comments contained in the remainder of the driver questionnaire. Comments on the questionnaire that are not present in this section are deemed to be self explanatory and no further discussion necessary.



(a) PROBLEM: Knee interference on acceleration

SOLUTION: Shorten Lever (b)





(c) SOLUTION: Ensure lever is as close to columr before operation

FIGURE 5 PROBLEM AND SOLUTIONS IN MAINTAINING FAST SPEEDS

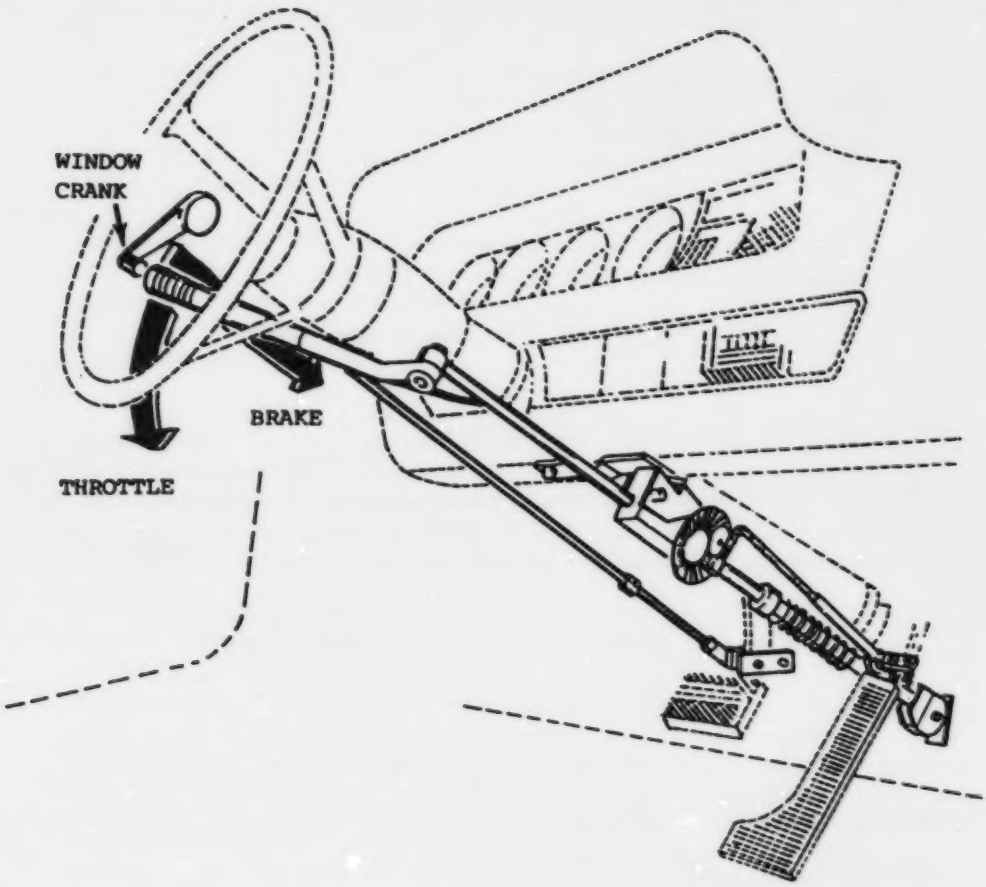


FIGURE 6 PROBLEMS IN STOPPING

- Little or no familiarization time needed before actual operation:

  This comment stems from the fact that 10 of the 11 respondents to question 3 (C), "which hand you use with your own control", answered left. The quick release mechanism is also left hand actuated.

- Tension adjustment - satisfactory for some but not others

  Over 50% of the drivers reported that they were happy with the tension, whereas the remainder were not. It is felt that this percentage could be reduced with the concessionaires becoming more vigilant with respect to installation adjustments.

- Tight space maneuvering:

  Transition from braking to throttling was documented as an anxiety. With the present length of the control arm, a small force applied for either braking or acceleration translates into a large force at the pedals. It is felt that a reduction in the control arm length would aid in reducing this anxiety. Also, familiarity and confidence should combine to eliminate the anxiety over time.

- Too familiar with the use of other hand control designs:

  Although 10 of 11 drivers now use left hand units, some brake and throttle actions vary from "push and rotate" to "push and pull". This factor could possibly be just cause for anxiety. This point could also support the earlier comment on the reduced learning curve effect of the handicapped due to lack of confidence and familiarity.

- Additional courtesy required for handicapped:

  This comment stems from a winter situation when outdoor access is restricted by snow and slush etc. Additional courtesy was offered by the concessionaire in the form of driving the rented car to an area which enabled easy wheelchair access.

- Solution needed to handicapped parking:

  The issuing of a handicapped parking permit is a time consuming process and cannot be expected to be carried out by the concessionaire without some form of surcharge. An

alternative solution is the use of handicapped parking stickers. It is anticipated that this solution will experience some abuse in the form of able bodied drivers exploiting the stickers. However, in this case, this solution seems to be the lesser of two evils.

3.6 COST/BENEFIT ANALYSIS

The figures used in the calculation have been generated through either the interpretation of the questionnaires, or estimation of the service being offered.

Simplistically put, the analysis is divided into the "cost" and "benefit" of the service. Benefit is termed as the annual savings; and cost, the annual cost.

$$\text{Cost} = [\text{initial cost}]\frac{A}{P} - [\text{Salvage}]\frac{A}{F}$$

(= 0 assumed)

$$\text{OR Cost} = [\text{initial cost}]\ \frac{i(1+i)^n}{(1+i)^n - 1}$$

where,

- initial cost of the unit is estimated to be \$800* plus an initial installation cost for the brackets (a mechanic at \$35 per hour for 4 hours).

  .. initial cost = 800 + 4(35) = \$940. dollars*

- salvage value of the unit is likely to be negligible,
- A is termed "uniform payments",
- F is termed "future amount",
- P is termed "present amount"
- i is interest per period (assumed to be 10%), and
- n is the number of compounding periods (assumed to be equal to the service life of the unit of 10 years)

$$\text{.. Cost} = 940\ \frac{0.1(1+0.1)^{10}}{(1+0.1)^{10}-1} = \$153.\ \text{dollars}$$

---

* Note that these costs are preliminary estimates and do not necessarily reflect the future market price.

Benefit on an annual savings basis is assumed to be the net return on a car rental over the course of the year. A number of assumptions and estimations had to be made to complete the calculation.

- It is estimated that $7.60 dollars of each $38.00 dollar daily rental can be used to offset the cost of the hand control unit.

- Frequency of rentals per concessionaire was calculated to be 3.3 rentals per year (as a result of the field trials).

- The average rental period was calculated to be 7½ days (as a result of the field trials).

- Utilization rate is considered to be the rate at which hand control unit requests could be accepted due to cars being readily available. Best case would be 100% utilization whereas a worst case would be 0%.

Thus, BENEFIT = 7.60 x 3.3 x 7.5 x 1.0 = $187 per year.
(Best Case) 1

BENEFIT = 7.6 x 3.3 x 7.5 x 0 = $0 per year.
(Worst Case)

Given the benefit per annum being greater than the costs per annum, the ratio will be greater than unity. The larger the ratio, the greater the benefit on a per annum basis.

In summation, the ratios below are the best and worst case scenarios.

$$\frac{\text{BENEFIT}}{\text{COST}} = \frac{187}{153} = 1.2 > 1 \quad \text{acceptable}$$
(Best Case)

$$\frac{\text{BENEFIT}}{\text{COST}} = \frac{0}{153} = 0 < 1 \quad \text{not acceptable}$$
(Worst Case)

It can be seen that the "best case" scenario is acceptable to implement whereas the worst case scenario obviously is not. In hindsight, making reference to the questionnaires and interviews conducted throughout the course of the project, the estimated "realistic scenario" would not lie with the best and worst case limits. Previous figures which would have to be altered in a realistic scenario would be:

(i) The utilization rate of 0% or a 100% would no longer apply. Based on the questionnaires, conversations with the concessionaires about peak and low periods and predicted public awareness, a utilization rate of 50% should be used.

(ii) The estimation of three to four rentals per year per agency is used based on the questionnaire responses alone. In light of the positive response apparent from the questionnaires and the fact that the field evaluation had limited market penetration, an estimate of 12 rentals per year could be used.

Making use of these two altered figures the benefit over cost ratio increases to;

$$\frac{\text{BENEFIT}}{\text{COST}} = \frac{342}{153} = 2.2 > 1 \quad \text{acceptable}$$

(Realistic)

Reproduced in a payback table it can be seen that the investment in one unit, under the assumptions of the analysis, pay for itself in under three years.

PAYBACK TABLE

YEAR	REALISTIC SCENARIO
0	- 940 dollars
1	- 598 "
2	- 256 "
3	86 "
4	428 "
5	770 "
6	1112 "
7	1454 "
8	1796 "
9	2138 "
10	2480 "

4.0 CONSIDERATIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

The ergonomic suitability of the quick release hand control unit in relation to its installation and removal (by the concessionaires) seems to be quite good. This is also true with respect to its actual use (by the drivers).

Of the identified minor problems, remedial solutions are readily available in the form of (i) minor alterations to the unit, or (ii) selection of the rental car and its options.

4.2 LIMITATIONS

The scope of this study is limited to the field evaluation of the quick release hand controls for handicapped drivers as perceived by the rental car concessionaires and the disabled drivers through the rental service offered.

Constraints placed on the study by the actual quick release hand control unit include:

- the quick release hand control unit is designed for handicapped drivers who have full dexterity of both hands, and were able to utilize a left handed control unit, and

- the use of the control unit, through the service offered, is limited to those persons who have a valid drivers permit with the appropriate hand controls' restriction.

A constraint apparent as a result of the rental service is that;

- the service is limited to those handicapped drivers who can afford the rental service offered.

And finally, a limitation imposed of this study by the questionnaire approach to field evaluations is;

- social desirability effects. For example; mechanics installing the hand control unit into rental cars might be more concerned with their performance in the eyes of their supervisor than documenting the problems they experienced during the installation. As a result response to the questionnaires did not contain as much information as would have been anticipated. The concessionaire questionnaires are effected more by desirability effects than the driver questionnaires.

4.3 RECOMMENDATIONS

Modifications to the quick release hand control unit as a result of the information obtained by the concessionaire responses include;

- construct locking pins larger with tapered ends to ease the connecting of tie rod ends to the respective brackets, and

- incorporate a stiffer spring into the accelerator tension mechanism.

A recommended modification to the unit as dictated by the analysis of the driver questionnaires involves;

- shortening of the control arm.

Other recommendations stemming from the analysis of driver questionnaires include;

- the selection of a car for use with the hand control units that has power windows, no console, folding bench seats and tilt steering, and

- the incorporation of an installation control arm adjustment into the Installation Instruction Manual (i.e. an added check for each individual installation).

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Koppa, R.J., McDermott, M. Raab, C., Sexton, D.J., Human Factors Anaylsis of Automotive Adaptive Equipment of Disable Drivers, Texas Transportation Institute, October 1980.

Dupuis, G., Car Controls Provide Freedom for the Disabled, Canadian Consumer, June 1981.

Tait, J., Transportation - Handicapped, Canadian Consumer, December 1980.

APPENDIX I

LIST OF CONTACTED ORGANIZATIONS

1984 HAND CONTROLS FIELD TRIALS

MAILING LIST

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APPENDIX II

BLANK FORMS
(Concessionaire and Questionnaire)

INSTALLATION/REMOVAL

1. In general, how easy did you find the overall task of installing and releasing the hand control system?

	Very Difficult	Somewhat Difficult	Fairly Easy	Very Easy
At first	.....	.....	.....	.....
By end of trial period	.....	.....	.....	.....

2. Estimate the time required by your personnel to:
   (a) install, inspect, and adjust the device: ..... min
   (b) remove the device from the vehicle: ..... min

TECHNICAL

1. Was any unscheduled maintenance performed on the quick-release hand control unit?

   ..... Yes ..... No

   Describe the nature of the maintenance or repair work (use a separate sheet if necessary)

   .....

   .....

   .....

   .....

2. How would you rate the overall reliability of the quick-release hand control unit?

   ..... Excellent ..... Fair ..... Poor

CONSUMER ACCEPTANCE

1. Did you receive any complaints from handicapped drivers regarding the quick-disconnect controls installed in your rental vehicles? ..... No ..... Yes (give details)

   .....

   .....

   .....

   .....

2. In general, the reaction of the handicapped customers to the hand control-equipped rental units was:

   ..... Positive ..... Indifferent ..... Negative

3. Did you receive any complaints from <u>non-handicapped</u> drivers regarding the quick-disconnect brackets installed in your rental vehicles?

   ..... No ..... Yes (give details)

   .....

   .....

   .....

   .....

UTILIZATION RATE

1. Start of survey period (date): ..... End of survey period (date): .....
2. Total no. of inquiries regarding hand control-equipped vehicle: .....
3. Actual no. of rentals of hand control-equipped vehicles during survey period: .....
4. Accumulated use of units: ..... km; ..... hrs
5. Based on the market reaction to the availability of hand control vehicles, how many hand control units would be required to satisfy the current and projected demands:
   Current Demand ..... units; Projected Demand ..... units
6. Did the rate of utilization of the rental fleet increase during the survey period?

   ..... Yes ..... No

7. If the answer to the above question is 'Yes', to what do you attribute this increase?

   ..... Availability of hand control units ..... Other (specify)

8. Did you have to turn down any requests for the hand control-equipped cars?

   ..... Yes ..... No

OPERATION	DIFFICULTIES Y=Yes N=No Description	COMMENTS AND/OR SUGGESTIONS
INSTALLATION 1 Position unit in car with columns toward floor and handle toward left		
2 Position attachment point on main column of assembly to bracket on steering column; insert shoulder locking pin from right to left through bracket and main column holes; insert hitch pin through hole at end of locking pin		
3 Position end of main column into floor bracket; insert locking pin from left to right through bracket and main column holes		
4 Position brake rod on brake pedal bracket; insert locking pin from left to right through bracket and brake column holes		
5 Position accelerator rod on throttle bracket; insert locking pin from left to right through bracket and accelerator rod holes		
6 To adjust accelerator tension, rotate collar on spring at base of main column; lock with wing nut bolt		
REMOVAL 1 To release accelerator tension, loosen wing nut bolt at base of main column; loosen collar on spring		
2 Grab ring in locking pin in brake pedal bracket; pull pin out leftward		
3 Grab ring in locking pin in throttle bracket; pull pin out leftward		
4 Grab ring in locking pin in floor bracket; pull pin out leftward		
5 Remove hitch pin from shoulder locking pin; grab ring of shoulder locking pin; pull out rightward		

DRIVER'S QUESTIONNAIRE

NAME OF RENTAL AGENCY: VEHICLE RENTED:	..... Date	COMMENTS AND/OR SUGGESTIONS

TRIP DETAILS

1. What is your estimate of your total kilometrage for this trip?

   ..... km

2. Give estimated percentages of city, rural, and highway driving this kilometrage represents:

   ..... % City ..... % Rural ..... % Highway

3. What is the most distant point you reached? .....

4. (a) Estimated Driving Time: ..... hrs; ..... min

   (b) Period Rented: ..... day(s)

5. Check (✓) one or more categories below, indicating the purpose of your trip:

   - business related to your job .....
   - personal business .....
   - visit(s) with friends, relatives .....
   - to attend a special event (e.g., sports, exhibition, etc.)

     name:..... .....
   - touring, sight-seeing, etc. .....
   - to reach a vacation spot (e.g., beach, cottage, etc.) .....
   - other (please specify):

     ....

GENERAL

1. (a) Age: ..... Under 20 ..... 21-35 ..... 35-50 ..... Above 50

   (b) Male/Female: ..... M ..... F

   (c) Present Occupation: .....

2. (a) No. of years of driving experience:

   ..... With Hand Controls ..... Without Hand Controls

   (b) Details of your <u>own</u> car (i.e., the one you regularly drive now at home or last drove at home):

   ..... Year ..... Make ..... Model

3. (a) Details of the hand controls in the car in Question 2(b) above:

   ..... Model ..... Make

   (b) Check (✓) the parts of your car for which you use a hand control:

   ..... Brake ..... Throttle ..... Dimmers ..... Other (specify)

   (c) Check (✓) which hand you use with your own controls:

   ..... Left ..... Right

4. How did you learn of this service?

   ..... Through Association For Disabled Persons (specify)
   ..... Concessionaire Advertising
   ..... Other (specify)

   .....

   .....

   .....

USE OF HAND CONTROL EQUIPPED VEHICLE: FORM D

1. Please complete the table below regarding operation of the vehicle that you rented with the hand controls.

OPERATION	DIFFICULTIES		IMPROVEMENT WITH PRACTICE	COMMENTS AND/OR SUGGESTIONS
	Y = Yes N = No	Description	0 = None 1 = Some 2 = Very Much	
Starting up				
Getting up to speed				
Maintaining fast speed				
Slowing down				
Stopping				
Turning right				
Turning left				
Switching lanes				
Passing a vehicle				
Backing up				
Parking: - parallel				
- other				
Signalling				
Using windshield wipers				
Using dimmers				
Using emergency brake				
Adjusting mirror				
Removing wheelchair				
Stowing wheelchair				
Other (specify)				

2. What aspects of the quick-release hand control units did you particularly like?

.....

.....

.....

.....

.....

.....

3. How was the hand control tension adjustment?

....

Too Stiff Too Loose Just Right

4. Describe any anxiety or discomfort you may have experienced regarding your use of the hand controls and/or the rental car.

.....

.....

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.....

SERVICE

1. Please comment briefly on the service offered and suggest methods of improving the existing service.

.....

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.....

GENERAL COMMENTS

You may use the space below to expand on any of the responses you have made in this questionnaire.

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THANK YOU FOR YOUR INTEREST AND COOPERATION.

APPENDIX III

SUMMARY OF CONCESSIONAIRES' RESPONSES TO THE GENERAL INFORMATION SECTION OF QUESTIONNAIRE FORM C

INSTALLATION/REMOVAL

1. In general, how easy did you find the overall task of installing and releasing the hand control system?

	Very Difficult	Somewhat Difficult	Fairly Easy	Very Easy
At first	.....	2	.....	1
By end of trial period	.....	.....	1	2

2. Estimate the time required by your personnel to:
   (a) install, inspect, and adjust the device: 12 min
   (b) remove the device from the vehicle: 3 min

TECHNICAL

1. Was any unscheduled maintenance performed on the quick-release hand control unit?
   1 Yes 2 No
   Describe the nature of the maintenance or repair work (use a separate sheet if necessary)
   (1) Tighten bolts before each rental (safety precaution and just plain common sense)

2. How would you rate the overall reliability of the quick-release hand control unit?
   3 Excellent Fair Poor

CONSUMER ACCEPTANCE

1. Did you receive any complaints from handicapped drivers regarding the quick-disconnect controls installed in your rental vehicles? 1 No 2 Yes (give details)
   (1) Control arm too close to windows crank
   (2) At full throttle, control arm close to leg

2. In general, the reaction of the handicapped customers to the hand control-equipped rental units was:
   3 Positive Indifferent Negative

3. Did you receive any complaints from non-handicapped drivers regarding the quick-disconnect brackets installed in your rental vehicles?
   3 No Yes (give details)
   (1) Suggestion - gas pedal bracket extended out a touch too far. Able bodied drivers toe would rest on bracket.
   - chrome on brackets started to flake after time

UTILIZATION RATE

1. Start of survey period (date): Aug/83 End of survey period (date): Nov/84
2. Total no. of inquiries regarding hand control-equipped vehicle: 9
3. Actual no. of rentals of hand control-equipped vehicles during survey period: 5-6
4. Accumulated use of units: 3028 km; 53.5 DAYS
5. Based on the market reaction to the availability of hand control vehicles, how many hand control units would be required to satisfy the current and projected demands:
   Current Demand 2 units; Projected Demand 2* units
6. Did the rate of utilization of the rental fleet increase during the survey period?
   2 Yes 3 No
7. If the answer to the above question is 'Yes', to what do you attribute this increase?
   Availability of hand control units advertizing Other (specify)
8. Did you have to turn down any requests for the hand control-equipped cars?
   Yes 3 No

* many, if available for sale

OPERATION	DIFFICULTIES			REMEDIAL ACTION
	yes	no	Problem description	Problem Solution
INSTALLATION				
1 Position unit in car with columns toward floor and handle toward left	0	4		
2 Position attachment point on main column of assembly to bracket on steering column; insert shoulder locking pin from right to left through bracket and main column holes; insert hitch pin through hole at end of locking pin	0	4		
3 Position end of main column into floor bracket; insert locking pin from left to right through bracket and main column holes	2	2	- not alot of room to insert pin	- design pins so they are easier to install
4 Position brake rod on brake pedal bracket; insert locking pin from left to right through bracket and brake column holes	0	4		
5 Position accelerator rod on throttle bracket; insert locking pin from left to right through bracket and accelerator rod holes	0	4		
6 To adjust accelerator tension, rotate collar on spring at base of main column; lock with wing nut bolt	1	3	- not enough tension - adjustment sometimes time consuming	- stiffer spring - larger wingnut for more leverage
REMOVAL				
1 To release accelerator tension, loosen wing nut bolt at base of main column; loosen collar on spring	0	4		
2 Grab ring in locking pin in brake pedal bracket; pull pin out leftward	0	4		
3 Grab ring in locking pin in throttle bracket; pull pin out leftward	0	4		
4 Grab ring in locking pin in floor bracket; pull pin out leftward	1	3	- space limitation	
5 Remove hitch pin from shoulder locking pin; grab ring of shoulder locking pin; pull out rightward	0	4		

APPENDIX IV

SUMMARY OF DRIVERS' RESPONSES TO THE GENERAL INFORMATION AND COMMENT SECTIONS OF QUESTIONNAIRE FORM D

FORM D

DRIVER'S QUESTIONNAIRE

NAME OF RENTAL AGENCY:
VEHICLE RENTED:

..... Date

COMMENTS AND/OR SUGGESTIONS

TRIP DETAILS

1. What is your estimate of your total kilometrage for this trip?

   .410..... km (S_x = 495)*

2. Give estimated percentages of city, rural, and highway driving this kilometrage represents:

   64 (S_x = 31) % City ; 7 (S_x = 14) % Rural ; 29 (S_x = 31) % Highway

3.** What is the most distant point you reached? .....

4. (a) Estimated Driving Time: 3 hrs; 40 min

   (b) Period Rented: ...7.4.(S_x.=.15.81..... day(s)

5. Check (✓) one or more categories below, indicating the purpose of your trip:

- business related to your job	7
- personal business	5
- visit(s) with friends, relatives	2
- to attend a special event (e.g., sports, exhibition, etc.) name:.....	0
- touring, sight-seeing, etc.	2
- to reach a vacation spot (e.g., beach, cottage, etc.)	0
- other (please specify):	1

GENERAL

1. (a) Age:

Under 20	21-35	35-50	Above 50
...0...	...8...	...2...	...4...

   (b) Male/Female:

M	F
...11..	...3...

   ***(c) Present Occupation: .....

2. (a) No. of years of driving experience:

   .18.(S_x.=.17)..... With Hand Controls

   ..3.(S_x.=.6)..... Without Hand Controls

   (b) Details of your own car (i.e., the one you regularly drive now at home or last drove at home):

   (SEE.COMMENT NUMBER.(2)).....

Year	Make	Model
		.....

3. (a) Details of the hand controls in the car in Question 2(b) above:

   (SEE.COMMENT.NUMBER.(3))

Model	Make
	.....

   (b) Check (✓) the parts of your car for which you use a hand control:

Brake	Throttle	Dimmers	Other (specify)
.....12.....	.....12.....	.....4.....	.....0.....

   (c) Check (✓) which hand you use with your own controls:

Left	Right
.....10.....	.....1.....

4. How did you learn of this service?

Through Association For Disabled Persons (specify)	Concessionaire Advertising	Other (specify)
.....8.....	.....2.....	.....5.....

   .....

   .....

   .....

1. (S_x = 2hrs, 43 min.)

2. compact - 2
   midsized - 6
   full sized - 4

** Questions 3 and 1(c), were originally included in the questionnaire for individual questionnaire reference only, should the meet have arised. For the "populations" representative questionnaire these two questions are meaningless to thus, has been left blank.

3. Wells Engberg - 4
   Whirlteq - 1
   Blatnik - 2
   Wright Way - 1
   Custon-made - 1

*** It should also be noted that the number of responses varied from question to question due to the fact that a driver could offer more than 1 reponse at all.

* S_x is the nomenclature for standard deviation

USE OF HAND CONTROL EQUIPPED VEHICLE: FORM D

1. Please complete the table below regarding operation of the vehicle that you rented with the hand controls.

OPERATION	DIFFICULTIES			IMPROVEMENT WITH PRACTICE				Remedial Action
	yes	no	Problem description	none	some	very much	n/a	Problem Solution
Starting up	2	12	- Stalling	4	0	1	9	-Vehicle tune-up familiazation with control
Getting up to speed	1	13		2	3	0	9	
Maintaining fast speed	2	12	- Control touched knee	3	2	0	9	-Shortening of control arm installation adjustment
Slowing down	1	13		2	2	0	10	
Stopping	3	11	- Gear Sticks - Control arm touches windows crank	3	0	1	10	-Installation adjustement shortening of Control Arm
Turning right	2	12	- Turn indicator too close	2	2	0	10	-Spinner knob suggested
Turning left	2	12		3	2	0	9	-Spinner knob suggested
Switching lanes	1	13	- Signalling difficulties	4	0	0	10	-Spinner knob suggested
Passing a vehicle	2	12	- Control touches knee	3	2	0	9	-Shortenning of control arm -Installation adjustment
Backing up	0	14		3	0	0	11	
Parking: - parallel	1	13		3	1	0	10	
- other	0	14		3	0	0	11	
Signalling	3	11	- Problems at full throttle (or brake) - too many levers for 1 hand	3	0	0	11	
Using windshield wipers	1	13	- See signalling	3	0	0	11	
Using dimmers	2	11	- See signalling	3	0	0	11	
Using emergency brake	4	5	- Foot operated	3	0	0	11	-Use hand to operate pedal
Adjusting mirror	4	10	- See signalling	2	0	0	12	
Removing wheelchair	6	5	- Console hinders process	5	2	0	7	-Shoulder height bucket seats required with no console. -folding bench seats
Stowing wheelchair	5	5	- Console hinders process	4	2	0	8	-Shoulder height bucket seats required with no console. -Folding bench seats.
Other (specify)								

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DTC 820
85
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2. What aspects of the quick-release hand control units did you particularly like?

(1) Little or no familiarization time needed before actual operation - 3
(2) Location of the hand control arm (i.e. left-handed, proximety to indicators) - 12
(3) Removal of the unit easy only for able bodied drivers - 1
(4) General positive statements on positiveness of hand controls - 5

3. How was the hand control tension adjustment?

4 Too Stiff — 3 Too Loose — 9 Just Right

4. Describe any anxiety or discomfort you may have experienced regarding your use of the hand controls and/or the rental car.

(1) Prefer spinner knob/tilt steering/electric windows - 2
(2) Range of movement of the control arm (fowards knee) to large - 5
(3) Tight space manovering - 4
(4) Too familiar with the use of other hand control designs - 2
(5) Rental car to large and powerful - 3
(6) Console binders the stowing of wheelchair - 3

SERVICE

1. Please comment briefly on the service offered and suggest methods of improving the existing service.

(1) Theneed for this service exists however, public awareness needed - 2
(2) Like to see this service offered in other than major centres - 1
(3) Additional courtesy required for handicapped (i.e. car to curb) - 2

GENERAL COMMENTS

You may use the space below to expand on any of the responses you have made in this questionnaire.

(1) General overall positive comment - 2
(2) Solution needed to handicapped parking - 1

THANK YOU FOR YOUR INTEREST AND COOPERATION.